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AUTHOR Ward, William H.
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ABSTRACT

Analysis of data, collected by the Minnesota Research and Evaluation Project during 1972, on high school biology, chemistry, and physics classes from 12 states in 3 regions of the United States showed no association between class size and student attitude toward science. Potential effects of teachers' attitudes toward science and students' achievement in science were compensated for. A slight correlation was found between cognitive achievement and class size. A moderate correlation was found between achievement in science and attitude toward science. Student and teacher attitude toward science was measured with the Science Attitude Inventory (SAI). Student achievement in science was measured with the Test of Achievement in Science. (Author/BB)

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RESEARCH PAPER #9

A Test of the Association of Class Size to Students' Attitudes Toward Science

William H. Ward

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Abstract

The possibility of an association between positive attitudes toward science among students and the size of a student's instructional unit was investigated using a sample of high school biology, chemistry, and physics students. Hypothesized potential masking effects due to teachers' attitudes toward science and due to students' achievement in science were identified and compensated for. The analysis disclosed no evidence for the existence of a significant association between class size and student attitudes. Slight correlation was found in the sample, however, between cognitive achievement and unit size, and moderate correlation between achievement in science and attitude toward science.

A Test of the Association of Class Size to Students' Attitudes Toward Science

William H. Ward

University of Minnesota

In increasing numbers, the objectives of science education programs explicitly include an affective component addressing the desirability for students to emerge with positive attitudes toward the scientific enterprise and its practitioners (Klopfer, 1971). This may well be appropriate, for a study concluded just prior to the appearance of one of the earliest NSF supported curriculum projects, PSSC Physics in 1957, reported high school students at that time generally held negative attitudes toward science and scientists (Heath, Maier, Remmers, and Rodgers, 1957).

One variable which may be directly controlled in attempts to gain objectives in attitudinal areas is the size of the instructional unit. There currently is no conclusive evidence for a relationship between cognitive achievement and class size (Shapson, 1972; Sitkei, 1968; Walberg, 1969), although much research has been done on the topic. In the affective area, however, Kahn and Weiss (1973) contend "...at present there is no research evidence on the affects of class size on affective learning" [p.779].

Two factors which might mask a class size-student attitude association are teacher attitudes toward science and student achievement in science. Reports of teacher-student attitude relationships are few. Notwithstanding, "...it would appear the relationship between teachers' and students' attitudes has been regarded as axiomatic..." [Kahn and Weiss, 1973, p.774].

Attitudes and cognitive achievement have been shown to be related (Bloom, 1971; Jackson, 1968), although attitudes were usually defined as attitudes toward the school as an institution or toward a specific class in the school rather than toward a discipline or field of endeavor.

One might logically question whether "attitude toward science" is necessarily a single, homogeneous construct. An alternative view could consider two segments: an intellectual attitude, that based upon some knowledge about the psychological object of the attitude, and an emotional attitude based upon a feeling or emotional reaction to the psychological object of the attitude. If, indeed, such a division does exist, the possibility of differing degrees of association with instructional unit size is raised.

This study sought to determine if a class size-student attitude association did exist among subjects in the data base of a large scale evaluation project, compensating for potential masking effects of teacher attitude and student achievement.

Method

Data Collection

Data used in this study are a portion of the baseline information collected by the Minnesota Research and Evaluation Project (MREP) during 1972 (Welch and Gullickson, 1973). High school biology, chemistry, and physics classes from twelve states in three regions of the United States comprise the sample.

MREP used the school as the basic experimental unit. All schools within a geographic area of interest were stratified by population, and each strata systematically sampled (Gullickson and Welch, 1972).

At each sample school, one teacher and one class of that teacher were randomly selected for study. To facilitate data gathering, achievement and attitude instruments were each written by a random third of the students in each class sampled (Walberg and Welch, 1967).

Variables

From the data available, eight variables were selected for use in this study.

1. Class Size.
2. Student Attitude Toward Science as measured with the Science Attitude Inventory (SAI), a Likert-type attitude measure designed to assess attitudes toward science. Reported reliability (test-retest) r = .93 (Moore and Sutman, 1970).
3. Student Achievement in Science as measured with the Test of Achievement in Science (TAS), a 45-item multiple choice instrument comprised of items selected from the National Assessment Test for Science (Lawrenz, 1972). Reliability (KR20) calculated from MREP sample r = .87 (Garibaldi, 1974).
4. Teacher Attitude Toward Science as measured with the SAI.
5. Student Emotional Attitude Toward Science.
6. Teacher Emotional Attitude Toward Science.
7. Student Intellectual Attitude Toward Science.
8. Teacher Intellectual Attitude Toward Science.

Variables one through four were available directly from the MREP data. The SAI, in addition to a total score, yields scores on six subscales, three purporting to measure intellectual attitudes and three emotional attitudes. Variables five through eight were constructed by summing scores on the appropriate subscales.

As a preliminary check on the question of homogeneity of "attitude," correlations were calculated between the variables designed to measure the intellectual and the emotional components for teacher and for student groups. Letting subscripts denote variables, these would be r_{57} and r_{68}. Results were $r_{57} = .58$ and $r_{68} = .51$. These were considered sufficiently low to retain the possibility of intellectual and emotional attitude being distinguishably different constructs. All eight variables were, thus, retained and the decision made to conduct three parallel analyses, one considering only emotional attitudes, one only intellectual attitudes, and one the sum of both components.

In this study, as in the MREP data, the class was used as the basic experimental unit (case); thus, values of variables 2, 3, 5, and 7, are class means for each individual case. Teacher attitude and class size were used directly as reported. Each case was weighted equally, regardless of class size.

Hypotheses

The questions at issue were whether smaller class sizes tended to be associated with higher (more positive) attitude scores when teacher attitude and student achievement differences were compensated for. The following hypotheses, as to partial correlation coefficients of class size and attitude measures adjusted for student achievement and teacher attitude, were considered:

H_o:	$r_{12.34} \geq 0$	class size - student total attitude partialing out student achievement and teacher total attitude
H_1:	$r_{12.34} < 0$	
H_o':	$r_{15.36} \geq 0$	class size - student emotional attitude partialing out student achievement and teacher emotional attitude
H_1':	$r_{15.36} < 0$	
H_o'':	$r_{17.38} \geq 0$	class size - student intellectual attitude partialing out student achievement and teacher intellectual attitude
H_1'':	$r_{17.38} < 0$	

with the decision to reject an H_o if $\alpha \leq .01$.

Analysis

All numerical analyses were performed using programs from the Statistical Package for the Social Sciences (SPSS) (Nie, Bent, and Hull, 1970). Descriptive statistics for each variable were computed and are shown in Table 1.

Insert Table 1 about here

Assuming the SAI as homogeneous across emotional and intellectual attitudes, variables 1, 2, 3, and 4 were first considered. The total correlation matrix was computed and a scatter plot was constructed for each variable pair to confirm that relationships were sufficiently linear for the analysis to proceed. First and second order partial correlations were computed from the correlation matrix. All correlations and their significance levels (one tail) are shown in Table 2.

Insert Table 2 about here

TABLE 1

Descriptive Statistics for Study Variables

Variable	$\bar{X}$	s	n[a]
1 (Class Size)	20.52	8.11	243
2 (Student Total Attitude)	110.42	7.93	242
3 (Student Achievement)	23.47	5.16	239
4 (Teacher Total Attitude)	127.11	12.33	234
5 (Student Emotional Attitude)	52.27	4.30	242
6 (Teacher Emotional Attitude)	61.48	6.25	234
7 (Student Intellectual Attitude)	58.16	4.62	242
8 (Teacher Intellectual Attitude)	65.62	7.81	234

[a]Differences in n reflect incomplete data for some cases.

TABLE 2

Correlations Considering Total SAI Scores

Item*	Correlation	Significance Level	df
r_{12}	-.26	< .01	242
r_{13}	-.32	< .01	237
r_{14}	-.10	.06	231
r_{23}	.63	< .01	236
r_{24}	.20	< .01	230
r_{34}	.22	< .01	229
$r_{23.1}$	.60	< .01	a
$r_{24.1}$	.18	< .01	a
$r_{34.1}$	.20	< .01	a
$r_{13.2}$	-.21	< .01	a
$r_{14.2}$	-.05	.21	a
$r_{34.2}$	.12	.04	a
$r_{12.3}$	-.08	.12	a
$r_{14.3}$	-.04	.29	a
$r_{24.3}$	.09	.10	a
$r_{12.4}$	-.24	< .01	a
$r_{13.4}$	-.30	< .01	a
$r_{23.4}$	.62	< .01	a
$r_{34.12}$	.11	.05	b
$r_{24.13}$	.08	.10	b
$r_{23.14}$	.59	< .01	b
$r_{14.23}$	-.03	.33	b
$r_{13.24}$	-.20	< .01	b
$r_{12.34}$	-.08	.13	b

[a]Significance level computed for 228 degrees of freedom.

[b]Significance level computed for 227 degrees of freedom.

*Subscripts reference variables - See Table 1.

The emotional attitudes portion of the SAI was then considered separately, and an identical procedure to that above was applied to variables 1, 3, 5, and 6. The correlations are shown in Table 3.

Insert Table 3 about here

Finally, the intellectual attitudes portion of the SAI was considered by processing variables 1, 3, 7, and 8. These correlations are shown in Table 4.

Insert Table 4 about here

Results

H_o ($r_{12.34} \geq 0$), H_o' ($r_{15.36} \geq 0$), and H_o'' ($r_{17.38} \geq 0$) each failed to be rejected at the .01 level of significance.

Discussion

No firm evidence was found to support the belief that better generation of positive attitudes toward science is associated with smaller instructional units.

The tests of the constructs "intellectual attitude" and "emotional attitude," proposed as being distinguishable components of "total attitude," produced similar results. This would suggest that total attitude is not readily divisible in this way or, alternatively, that the methods here used were too crude and superficial to detect a true underlying division.

Two pairs of factors, class size-achievement and achievement-attitude, did produce consistently higher correlations on all three runs: emotional,

TABLE 3

Correlations Considering Emotional SAI Scores

Item *	Correlation	Significance Level	df
r_{13}	-.32	< .01	237
r_{15}	-.17	< .01	240
r_{16}	-.02	.40	231
r_{35}	.48	< .01	236
r_{36}	.13	.02	231
r_{56}	.07	.13	230
$r_{35.1}$	.46	< .01	a
$r_{36.1}$	.13	.02	a
$r_{56.1}$	.07	.14	a
$r_{15.3}$	-.02	.36	a
$r_{16.3}$	.03	.34	a
$r_{56.3}$	.01	.44	a
$r_{13.5}$	-.27	< .01	a
$r_{16.5}$	-.004	.48	a
$r_{36.5}$	.11	.05	a
$r_{13.6}$	-.32	< .01	a
$r_{15.6}$	-.17	< .01	a
$r_{35.6}$	.48	< .01	a
$r_{56.13}$	.01	.43	b
$r_{36.15}$	.11	.04	b
$r_{35.16}$	.45	< .01	b
$r_{16.35}$	.03	.34	b
$r_{15.36}$	-.02	.36	b
$r_{13.56}$	-.27	< .01	b

[a]Significance level computed for 229 degrees of freedom.

[b]Significance level computed for 228 degrees of freedom.

*Subscripts reference variables - See Table 1.

TABLE 4

Correlations Considering Intellectual SAI Scores

Item*	Correlation	Significance Level	df
r_{13}	-.32	< .01	237
r_{17}	-.28	< .01	240
r_{18}	-.15	.01	231
r_{37}	.64	< .01	236
r_{38}	.24	< .01	229
r_{78}	.30	< .01	230
$r_{37.1}$	.60	< .01	a
$r_{38.1}$	.20	< .01	a
$r_{78.1}$	.27	< .01	a
$r_{17.3}$	-.11	.05	a
$r_{18.3}$	-.08	.12	a
$r_{78.3}$	.20	< .01	a
$r_{13.7}$	-.19	< .01	a
$r_{18.7}$	-.07	.15	a
$r_{38.7}$	.06	.16	a
$r_{13.7}$	-.29	< .01	a
$r_{17.8}$	-.25	< .01	a
$r_{37.8}$	.61	< .01	a
$r_{78.13}$	.19	< .01	b
$r_{38.17}$	.05	.21	b
$r_{37.18}$	.58	< .01	b
$r_{18.37}$	-.06	.19	b
$r_{17.39}$	-.10	.07	b
$r_{13.78}$	-.18	< .01	b

[a]Significance level computed for 228 degrees of freedom.

[b]Significance level computed for 227 degrees of freedom.

*Subscripts reference variables - See Table 1.

intellectual, and composite. They were in all instances significantly different from zero at the .01 level. It should be remembered, however, that the number of cases in this study was moderately large and, in such instances, even small correlations become statistically significant. Realistically, there are few variables in schools which are truly totally independent of each other, and one's practical concern should be with the amount of implied association.

The consistent association of achievement to class sizes is somewhat at odds with many other studies mentioned in the reviews cited above (Shapson, 1972; Sitkei, 1968). One explanation is that this may be a spurious effect due to the nature of the MREP data. Students were not assigned randomly to various sized classes but, rather, sampled as they were found. Schools which continuously and systematically produce students scoring highly on achievement measures are inclined to be those financially able to support smaller classes. An alternate explanation, of course, is that the association, though weak, does, in truth, exist.

The strong association between achievement and both intellectual and emotional attitudes cannot be denied. Bloom (1971) proposes that attitude-achievement associations are functional, in that advancement in one promotes advancement in the other in a sort of bootstrap fashion. If this is so in the particular case of attitudes toward and achievement in science--and one must admit to the obvious surface logic of such a relationship--several implications may be drawn. Generalized objectives may continue to be formulated from both domains; however, we are currently far more skilled in defining, measuring, and devising instructional schemes to work achievement of those in the cognitive. The existence of a functional relationship

would suggest that by merely treating cognitive concerns effectively one would be provoking advancement on the affective front, as well. This is not a valid rationalization for ignoring explicitly affective objectives, since the converse of the relationship would equally hold, and effective treatment of affective objectives would be expected to also produce cognitive advancement. The postulated interactive nature of the domains would warrant a bifrontal approach. A functional relationship thus implies attainment of affective objectives may be proceeded toward by utilizing to the fullest our considerable technique in cognitive instruction while developing a comparable sophistication in the affective domain. When these affective techniques are developed and applied, an expected secondary effect would be cognitive advancement.

Returning to the initial issue of instructional unit size, it would seem, in view of the above, that the proper question would be whether unit size is associated with achievement of objectives in either cognitive or affective areas. The bulk of the evidence seems to indicate not, the slight association to cognitive achievement found by this study notwithstanding. In simply counting heads, however, a basic premise of differential unit size can be overlooked, that being the differential hospitality of differing sizes to various teaching strategies and instructional systems. The assumption that these differences are exploited fully in each situation, thus maximizing the potential of the particular unit size, is often not justified. Perhaps a proper first step toward more ultimate goals would be to work to more closely match teaching methods to the size of the unit in which they are employed. Better judgments could then be made as to the comparative utility of differing size units as educational settings.

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